MIND, BRAIN, AND EDUCATION

Going Beyond Mathematics Anxiety in Primary and Middle School Students: The Role of Ego-Resiliency in Mathematics

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ABSTRACT— Previous research examined the influence of math anxiety (MA) on performance in mathematics, but few studies compared the contribution of MA to other forms of anxiety, such as test and general anxiety (GA). Unlike MA, ego-resiliency promotes the management of challenges, and has been positively associated with mathematics performance. In this study, we investigated the specific influence of MA, test- and GA, and ego-resiliency on mathematics performance after controlling for intelligence. Children from grades 5 to 8 ($N = 274$) were assessed with self-report tools measuring MA, test and GA, and ego-resiliency, and completed intelligence and mathematical tasks. The results of structural equation models showed that MA had a main negative effect on mathematics performance, over and above the effect of test- and GA. Ego-resiliency had a positive effect on mathematics performance, and was negatively associated with GA. Our findings are discussed in terms of the implications for intervention programs to reduce anxiety and sustain ego-resiliency.

Mathematics is often considered one of the most difficult and demanding school subjects from early on, not only because of the complex skills required, but also due to negative attitudes often associated with its learning (Mammarella, Caviola, & Dowker, 2019). Such negative attitudes are often described as *math anxiety* (MA), and involve feelings of tension, worry, and apprehension regarding current or prospective situations involving mathematics (Ashcraft & Moore, 2009; Richardson & Suinn, 1972). The concerning phenomenon of MA has been considered in one of the most important international surveys of 15-year-old students' school achievement conducted in numerous countries all over the world—the Programme for International Student Assessment (PISA). The results of the 2012 PISA survey indicated that 30% of students felt powerless or nervous when faced with mathematical problems, and also performed less well than expected in mathematics (Organization for Economic Cooperation and Development [OECD], 2013).

Mathematical performance (Hembree, 1990; Ma, 1999; Namkung, Peng, & Lin, 2019), and is associated with other forms of anxiety, such as test- and general anxiety (GA) (Hembree, 1988, 1990). Recent studies indicate that all these forms of anxiety can contribute to a sense of fear and discomfort regarding mathematics (Devine, Fawcett, Szűcs, & Dowker, 2012; Hill et al., 2016). What is still not clear, however, is the degree to which MA specifically affects mathematics achievement, once any other forms of anxiety (i.e., test- and GA) have been taken into account (Carey, Devine, Hill, & Szűcs, 2017; Mammarella, Donolato, Caviola, & Giofrè, 2018).

On the other hand, children are equipped with such personal assets or individual resources as resilience, self-concept, and self-efficacy, that act as protective factors when they face difficulties or stressful situations (Garmezy, 1991; Windle, 2011). Among these positive attitudes, children's ego-resiliency has a key role because it facilitates the management of various challenges in their academic live, with a positive effect on the outcome (e.g., Eisenberg

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et al., 1997; Swanson, Valiente, Lemery-Chalfant, & Caitlin O'Brien, 2011). Some studies have looked at the positive interplay between school-related emotions, resilience, and academic achievement, but few have assessed children's ego-resiliency or its interplay with different forms of anxiety (Pekrun, Lichtenfeld, Marsh, Murayama, & Goetz, 2017; Putwain & Daly, 2013; Struthers, Perry, & Menec, 2000). The present study aimed to shed more light on this topic. We argue that mathematics is a subject in which children face several difficulties (Ashcraft & Moore, 2009), but more ego-resilient children might cope better with these challenges (Alessandri, Zuffianò, Eisenberg, & Pastorelli, 2017; Kwok, Hughes, & Luo, 2007).

As regards schooling, research suggests that MA and test anxiety (TA) are both negatively associated with academic success (Ma, 1999; Namkung et al., 2019; von der Embse, Jester, Roy, & Post, 2018). MA involves feelings of tension, worry and apprehension regarding current or prospective situations involving mathematics (Ashcraft & Moore, 2009; Carey, Hill, Devine, & Szücs, 2016; Mammarella et al., 2019; Richardson & Suinn, 1972). Students who experience MA are more likely to perform poorly in mathematics (Ma, 1999; Namkung et al., 2019; Vukovic, Kieffer, Bailey, & Harari, 2013; Wu, Barth, Amin, Malcarne, & Menon, 2012). TA is a form of anxiety in which feelings of apprehension and distress are prompted by test/assessment situations (Zeidner, 2007). Students who suffer from TA perform less well than they might in all sorts of academic subject, including English, science, mathematics, and social science (McDonald, 2001; von der Embse et al., 2018). While MA and TA differ in some respects, a key issue to consider when studying them concerns their relationship with GA (Carey et al., 2017; Hill et al., 2016). GA differs from MA and TA in that it is not related to any specific situation, but rather to an individual's tendency to worry about events, their behavior, and their abilities (Eysenck & Calvo, 1992). Some studies have made the point that MA, TA, and GA are distinct, but related aspects. Meta-analyses of studies conducted on high-school and college students identified a closer association between MA and TA, while GA emerged as more clearly distinct from either MA or TA (Dew, Galassi, & Galassi, 1984; Hembree, 1988, 1990; see also Lauer, Esposito, & Bauer, 2018). That said, not much research has been done on the relationship between MA, TA and/or GA and mathematics performance (Carey et al., 2017; Devine et al., 2012; Hill et al., 2016; Xie, Xin, Chen, & Zhang, 2019). Further studies will be essential to better clarify the nature of these constructs and confirm the specific influence of MA on achievement in mathematics (Ashcraft, Krause, & Hopko, 2007; Carey et al., 2017; Mammarella et al., 2019).

Unlike anxiety, several personal assets—such as self-efficacy and resilience—have been found to sustain positive life outcomes and academic success (Bandura, 1993; Eisenberg et al., 1997; Masten, 2001). Self-efficacy represents individuals' expectations and convictions about their own abilities, and what they can accomplish in a given situation (Tsang, Hui, & Law, 2012). Resilience (often called ego-resiliency) is a pattern of individual features such as general resourcefulness, strength of character, and flexibility of functioning, that enables people to recover quickly from difficulties and day-to-day challenges (Block & Block, 1980; Fletcher & Sarkar, 2013). At school, ego-resiliency helps children to cope with potentially stressful situations by fostering their competence and enabling them to focus their efforts when under evaluation (Martin & Marsh, 2006; Smith & Carlson, 1997; Swanson et al., 2011). Children who are more ego-resilient adapt more quickly; they are more flexible in using problem-solving strategies; and they are more persistent in achieving their academic goals (Alessandri et al., 2017; Kwok et al., 2007).

Although no previous research directly addressed the relationship between ego-resiliency and different forms of anxiety (MA, TA, and GA), some studies did lay the groundwork for hypotheses on how these constructs may variously relate to mathematics performance. For a start, ego-resilient individuals reported better adjustment and fewer internalizing problems, including anxiety (Block & Gjerde, 1990; Chuang, Lamb, & Hwang, 2006; Huey & Weisz, 1997). Earlier research revealed a negative association between ego-resiliency and anxiety, with ego-resiliency protecting against anxiety from early childhood (Chuang et al., 2006). In contrast, scarcely ego-resilient individuals have poor adaptive abilities and limited flexibility, predisposing them to more severe internalizing problems (Milioni, Alessandri, Eisenberg, Vecchione, & Caprara, 2015; Wolfson, Fields, & Rose, 1987). A similar mechanism may be involved in other specific forms of anxiety, such as MA and TA. In fact, resilience was found negatively associated with TA in supporting academic performance (Putwain, Nicholson, Connors, & Woods, 2013). Taken together, these findings suggest that ego-resiliency might correlate negatively not only with GA, but also with MA or TA. It might therefore be an important resource for managing school challenges and emotional difficulties, especially in the context of math-related achievement (Alessandri et al., 2017; Kwok et al., 2007), since mathematics is a complex subject, and often reported as one of the most demanding and stressful to learn (Ashcraft et al., 2007). Being related to mental flexibility, ego-resiliency might have a key role in coping with potential difficulties in mathematics (Dreke, 2009; Kwok et al., 2007).

The present study aimed to examine the specific contributions of MA, TA, GA, and ego-resiliency to mathematics performance in primary-school and middle-school children. We examined the contribution of these constructs in terms of their main effect on mathematics performance once the role of fluid intelligence had been taken into account. We expected MA to have a greater negative effect on mathematics performance than TA or GA, in line with other studies (e.g., Carey et al., 2017; Hill et al., 2016; Wu et al., 2012). We also expected to find a positive relationship between ego-resiliency and mathematics performance, consistently with previous research (Alessandri et al., 2017; Kwok et al., 2007). We hypothesized a negative relationship between ego-resiliency and both MA and TA, given that it is negatively related to GA (Chuang et al., 2006; Huey & Weisz, 1997), and that GA, TA, and MA are related constructs (Hembree, 1988, 1990). We assumed that ego-resiliency—being related to flexibility, problem-solving strategies and maintaining effort—provides children with more resources for coping with mathematics, which is one of the most difficult and stressful subjects taught at school (Devine, Hill, Carey, & Szűcs, 2018).

METHOD

Participants

The present study was conducted on 264 children (47% girls, $M_{age} = 11.27$ years, $SD = 1.32$; range = 9.00–15.00 years) attending grades from 5 to 8, at state schools in urban areas of north-east Italy. The children and their parents came from working-class and middle-class families. Around 90% of the children were native Italian speakers, while the remainder were fluent in the language, and had received at least 3 years of formal education in Italy. Only typically developing children were included in the sample. The study was approved by the Ethics Committee on Psychology Research at the University of Padova. After each school's approval, written informed parental consent was obtained before testing the children.

Materials

For all self-report scales, the internal consistency (Cronbach's α) was calculated on the matrices of polychoric correlations. This approach was chosen because it is more appropriate for items on a binomial (e.g., "yes"/"no") or ordinal (e.g., Likert) scale (Zumbo, Gadermann, & Zeisser, 2007). The final measures for the subscales were obtained as the sum of the scores, however.

General Anxiety. The *Revised Children's Manifest Anxiety Scale, Second Edition* (RCMAS-2; Reynolds & Richmond, 2012) is a self-report questionnaire for detecting GA in children and adolescents. It comprises 49 items with a yes/no response format, with higher scores indicating greater anxiety. The questionnaire provides scores on different subscales concerning worries (e.g., "*I am worried that my classmates could make fun of me*"), physiological anxiety (e.g., "*I often have stomachache*"), and social anxiety (e.g., "*I feel nervous when things don't go as I want*"). As responses are given on a binomial scale ("yes"/"no"), the internal consistency was calculated using a method for ordinal data, i.e., on the matrix of the tetrachoric correlations. The internal consistency of the scale in the present sample was good for all three subscales: worries (polychoric Cronbach's α = .77); physiological anxiety (polychoric Cronbach's α = .77); and social anxiety (polychoric Cronbach's α = .86).

Test Anxiety. The *Test Anxiety Questionnaire for Children* (TAQ-C; Donolato, Marci, Altoè, & Mammarella, 2019) is a self-report tool for assessing TA in primary- and middle-school children. Children read 24 items and rate each item using a 4-point Likert scale from 1 = "never" to 4 = "always". The questionnaire provides scores on four different subscales about thoughts (e.g., "*I think I'm going to get a bad grade*"), off-task behavior (e.g., "*I play with my pencil*"), autonomic reactions (e.g., "*My heart beats fast*"), and social derogation (e.g., "*I'm worried that all my friends will get high scores in the test and only I will get low ones*"). The internal consistency in the present sample was good for all four subscales: thoughts (polychoric Cronbach's α = .87); off-task behavior (polychoric Cronbach's α = .81); autonomic reactions (polychoric Cronbach's α = .85); and social derogation (ordinal Cronbach's α = .88).

Mathematics Anxiety. The *Abbreviated Math Anxiety Scale* (AMAS; Caviola, Primi, Chiesi, & Mammarella, 2017; Hopko, Mahadevan, Bare, & Hunt, 2003) is a brief self-report tool for measuring MA in children. The questionnaire comprises nine items scored on a 5-point Likert scale from 1 "strongly agree" to 5 "strongly disagree". Children judged each statement describing different situations involving mathematical activities at school in terms of how anxious they would feel. The questionnaire provides scores on subscales for math learning anxiety (e.g., "*Listening to a lecture in math class*") and math testing anxiety (e.g., "*Thinking about an upcoming math test 1 day before*"). In the present sample, a good internal consistency was observed for both subscales (polychoric Cronbach's α = .81 in both cases).

Ego-Resiliency. The *Ego Resiliency Scale* (ER; Block & Kremen, 1996) is a questionnaire for assessing individual features such as general resourcefulness, strength of character, and flexibility of functioning that can help individuals to adapt more quickly to changing circumstances. The questionnaire comprises 14 statements (e.g., "*I quickly get over and recover from being startled*") scored on a 4-point Likert scale, from 1 "does not apply at all" to 4 "applies very strongly". The internal consistency of the questionnaire in the present sample was adequate (polychoric Cronbach's α = .76).

Mathematical Achievement. *The INVALSI* (Italian Institute for the Assessment of the Education System, 2011) aims to assess academic achievement in *mathematics*. The INVALSI tests provide scores in four areas: *space and figures* (MATH-SF), relating to geometry problems; *numbers*

(MATH-N), consisting of number fractions and other mathematical calculations; *relations and functions* (MATH-RF), including problems with equivalences or algebraic expressions; and *data and prediction* (MATH-DP), involving probability and statistical problems. The appropriate version of the INVALSI test was proposed for each school grade. The task showed a good psychometric internal consistency in the present sample (polychoric Cronbach's $\alpha = .92$ in grade 5, $\alpha = .93$ in grade 6, and $\alpha = .87$ in grade 8).

Intelligence. The *Cattell Culture Fair Intelligence Test* (CFIT; Cattell & Cattell, 1981) is a test for measuring fluid intelligence. It consists of 46 multiple-choice items divided into four timed subtests (series completion, odd-one-out, matrices, and topology) covering judgments and reasoning, with items of increasing difficulty in each subtest. As reported in the manual, the CFIT has a good internal consistency (Cronbach's $\alpha = .76$).

Procedure

Participants were tested during two group sessions: (1) one lasting approximately 45 min, conducted during the first semester, to administer the questionnaires and intelligence measure; and (2) one lasting approximately 75 min, scheduled during the second semester, for assessing mathematical achievement. All tasks were administered in children's classrooms by a trained assistant researcher using a standardized procedure and in the presence of the teacher. In the first session, children were administered the CFIT, the RCMAS-2, the ER, the TAQ-C, and the AMAS. In the second session, participants sat the INVALSI mathematical achievement test.

Statistical Analyses

Analyses were performed using the R statistical software (R Development Core team, 2016). Item Response Theory (IRT) scaling was used to make the results comparable for the INVALSI task, in which different versions were used for each grade (Cook & Eignor, 1991). Then, all observed measures were residualized by grade to control for this confounding variable. None of the 264 participants had any data missing for a whole subscale. The few data missing from their responses to single items (i.e., only 0.3% of the total) were examined and input on the basis of each child's average score on their valid responses in the subscale considered before model fitting.

A two-step modeling approach was used (Kline, 2016), with confirmatory factor analyses (CFAs) and structural equation models (SEMs). Analyses were performed with the *lavaan* package (Rosseel, 2012). The maximum-likelihood-based estimation method was used, with robust standard errors and a Satorra-Bentler scaled test statistic (Satorra & Bentler, 1994). The model's goodness-of-fit was examined using several indexes, the chi-square (χ^2), the comparative fit index (CFI), the non-normed fit index (NNFI), the standardized root mean square residual (SRMR), and the root mean square error of approximation (RMSEA) (Hu & Bentler, 1999). The Akaike information criterion (AIC) was used to compare the fit of alternative models (Kline, 2016).

An a priori power analysis indicated that 258 subjects were needed to have a 90% power for detecting a hypothesized effect of −.20 between MA and mathematical achievement when employing the traditional .05 criterion of statistical significance. This effect was expected considering: that a meta-analysis reported an association between MA and mathematical performance of $r = -.27$ (Ma, 1999); and that we aimed to estimate this effect after taking the role of GA, TA, ego-resiliency and fluid intelligence into account. Such a sample size was also in line with the Bollen (1989) rule of thumb that 5–10 observations are needed per estimated parameter in SEMs (in all models presented below, there were >5 participants per parameter).

RESULTS

Descriptive statistics (means and standard deviations) and correlations are presented in Table 1. Analysis of the skewness and kurtosis showed no major deviations from normality. For skewness, all coefficients were <1 in absolute values (for a normal distribution, skewness = 0). For kurtosis, all coefficients were in the [2, 5] range (for a normal distribution, kurtosis = 3).

CFA Models

A measurement model was developed, aiming to fit the hypothesized latent variables (Kline, 2016). In the CFA-01, we estimated six latent variables: GA, TA, MA, ego-resiliency (RES), fluid intelligence (*g*F), and mathematical achievement (MATH). The RES error was fixed using the 1-reliability^2 formula (see Kline, 2016, for more details). The model showed an adequate fit, $\chi^2(121) = 211.24$, $p < .001$, RMSEA = .05, SRMR = .05, CFI = .94, NNFI = .92, and was therefore retained for the subsequent analyses. Factor loadings and interfactor correlations are given in Table 2.

SEM Models

We started with a model (SEM01) in which GA, TA, MA, RES, and *g*F were exogenous and correlated with each other, while MATH was endogenous. When compared with the measurement model, SEM01 maintained the same relationships among all latent variables (the only difference being that some correlations were treated as regression paths), and the fit was identical by definition (see Kline,

Table 1
Correlations (After Residualizing by School Grade) and Descriptive Statistics (Means and Standard Deviations)

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*
1. RCMAS-2 PA	—																	
2. RCMAS-2 WO	.542	—																
3. RCMAS-2 SO	.458	.675	—															
4. TAQ-C PA	.325	.392	.429	—														
5. TAQ-C THO	.265	.318	.410	.581	—													
6. TAQ-C OFF	.384	.240	.257	.374	.389	—												
7. TAQ-C SOC	.292	.384	.528	.550	.727	.282	—											
8. MLA	.121	.183	.232	.142	.241	.120	.282	—										
9. MTA	.234	.306	.341	.419	.387	.218	.372	.590	—									
10. ER	−.115	−.138	−.261	.020	−.051	−.101	−.085	−.088	.050	—								
11. Cattell 1	.015	−.006	.021	−.006	−.017	.084	−.055	−.102	−.057	.139	—							
12. Cattell 2	−.067	−.041	−.046	−.008	−.077	.039	−.103	−.159	−.130	−.038	.303	—						
13. Cattell 3	−.067	.032	−.105	−.067	−.058	−.010	−.148	−.181	−.177	.021	.367	.395	—					
14. Cattell 4	.054	−.003	−.033	.101	.055	.121	−.041	−.120	−.087	.004	.214	.296	.314	—				
15. MATH-N	−.080	−.088	−.180	−.118	−.201	−.073	−.211	−.334	−.257	.125	.225	.268	.396	.275	—			
16. MATH-SF	−.062	−.047	−.124	.017	−.101	−.021	−.146	−.212	−.111	.101	.289	.197	.237	.243	.533	—		
17. MATH-DP	−.060	−.028	−.153	−.052	−.120	.009	−.175	−.293	−.169	.123	.184	.227	.265	.232	.553	.488	—	
18. MATH- RF	−.086	−.120	−.167	−.042	−.117	.002	−.136	−.267	−.163	.093	.230	.268	.385	.229	.549	.393	.468	—
M	50.59	50.85	50.39	11.20	13.65	12.32	11.26	2.13	3.04	41.22	8.44	7.29	8.38	4.70	41.78	39.84	47.47	38.80
SD	10.13	9.28	9.31	3.78	4.02	4.04	4.25	0.88	1.07	5.60	1.75	1.77	2.35	1.82	21.21	20.73	23.07	21.90

Note. $N = 264$. All coefficients $\geq .121$ are significant at .05 level. Means and standard deviations for MATH were calculated on the proportion of correct answers, before IRT scaling. RCMAS-2 = general anxiety scale; -PA = physiological subscale; -WO = worries subscale; -SO = social subscale; TAQ-C = test anxiety scale; -PA = physiological subscale; -THO = thoughts subscale; -OFF = off-task behavior; -SO = social subscale; AMAS = mathematical anxiety scale; ER = ego-resiliency scale; Cattell = intelligence scale; MATH = mathematical literacy; MLA = math learning anxiety; MTA = math testing anxiety; -N = numbers; -SF = space and figures; -DP = data and prediction; -RF = relations and functions.

Table 2
Factor Loadings, Interfactor and Residual Correlations for the Final Measurement Model

	GA	*TA*	*MA*	*RES*	*gF*	*MATH*
1. RCMAS-2 PA	.59					
2. RCMAS-2 WO	.79					
3. RCMAS-2 SO	.85					
4. TAQ-C PA		.70				
5. TAQ-C THO		.84				
6. TAQ-C OFF		.43				
7. TAQ-C SO		.84				
8. MLA			.66			
9. MTA			.89			
10. ER				.75		
11. Cattell 1					.48	
12. Cattell 2					.53	
13. Cattell 3					.68	
14. Cattell 4					.45	
15. MATH-N						.82
16. MATH-SF						.64
17. MATH-DP						.68
18. MATH-RF						.68
Interfactor correlation matrix						
GA	1					
TA	.631**	1				
MA	.436**	.520***	1			
RES	−.328**	−.094	−.031	1		
*g*F	−.028	−.127	−.292**	.042	1	
MATH	−.209*	−.236**	−.349***	.210*	.711**	1

Note. All factor loadings are significant ($p < .01$). RCMAS-2 = general anxiety scale; -PA = physiological subscale; -WO = worries subscale; -SO = social subscale; TAQ-C = test anxiety scale; -PA = physiological subscale; -THO = thoughts subscale; -OFF = off-task behavior; -SO = social subscale; AMAS = mathematical anxiety scale; ER = ego-resiliency scale; Cattell = intelligence scale; MATH = mathematical literacy; -N = numbers; -SF = space and figures; -DP = data and prediction; -RF = relations and functions; GA = general anxiety; TA = test anxiety; MA = mathematics anxiety; RES = ego-resiliency factor; *g*F = general intelligence.
Interfactor correlations, $^{*}p < .05$, $^{**}p < .01$.

2016). We therefore assessed the full model. We dropped small and statistically insignificant correlations and path coefficients, one at a time, until we obtained a final model that would only include all relevant paths and correlations). First we removed the nonsignificant correlations between the exogenous variables, starting with those with the smallest standardized coefficients. Then we removed the nonsignificant paths from the exogenous variables to the endogenous one, again starting from those with the smallest coefficients. The final model only had statistically significant paths. Notably, the result was exactly the same when we started by removing paths rather than correlations. The final model (SEM02) showed an adequate fit, $\chi^2(128) = 218.03$, $p < .001$, RMSEA = .05, SRMR = .06, CFI = .94, NNFI = .93 (see Figure 1). Although the chi-square value was statistically significant, the ratio between this value and its degrees of freedom indicated a good fit of the model. The AIC showed that the SEM02 had a better fit than the SEM01, ΔAIC = −7.20. In the final model, MA and RES revealed opposite but similarly-sized effects on MATH ($\beta = -.21$, $p < .01$ and $\beta = .20$, $p < .01$, respectively). These results are robust and remained even after controlling for *g*F.

In the Appendix, we report further results: (1) a sensitivity analysis for multivariate outliers; (2) a sensitivity analysis to test whether the paths were affected by gender differences; (3) the moderating effect of ER on the relationship between MA and MATH; and (4) a variance partitioning analysis to examine the unique and shared portion of variance explained by MA, TA, and GA on MATH.

DISCUSSION

The present study aimed to help fill the research gap on the role of ego-resiliency, MA, TA, and GA in the learning of mathematics, focusing on primary- and middle-school students. We assumed that MA would make a unique (negative) contribution to mathematical performance when compared with TA and GA (Carey et al., 2017). We also expected ego-resiliency to have a positive effect on mathematics performance (Alessandri et al., 2017; Kwok et al., 2007), and negative associations with MA, TA, and GA (Chuang et al., 2006; Huey Jr. & Weisz, 1997).

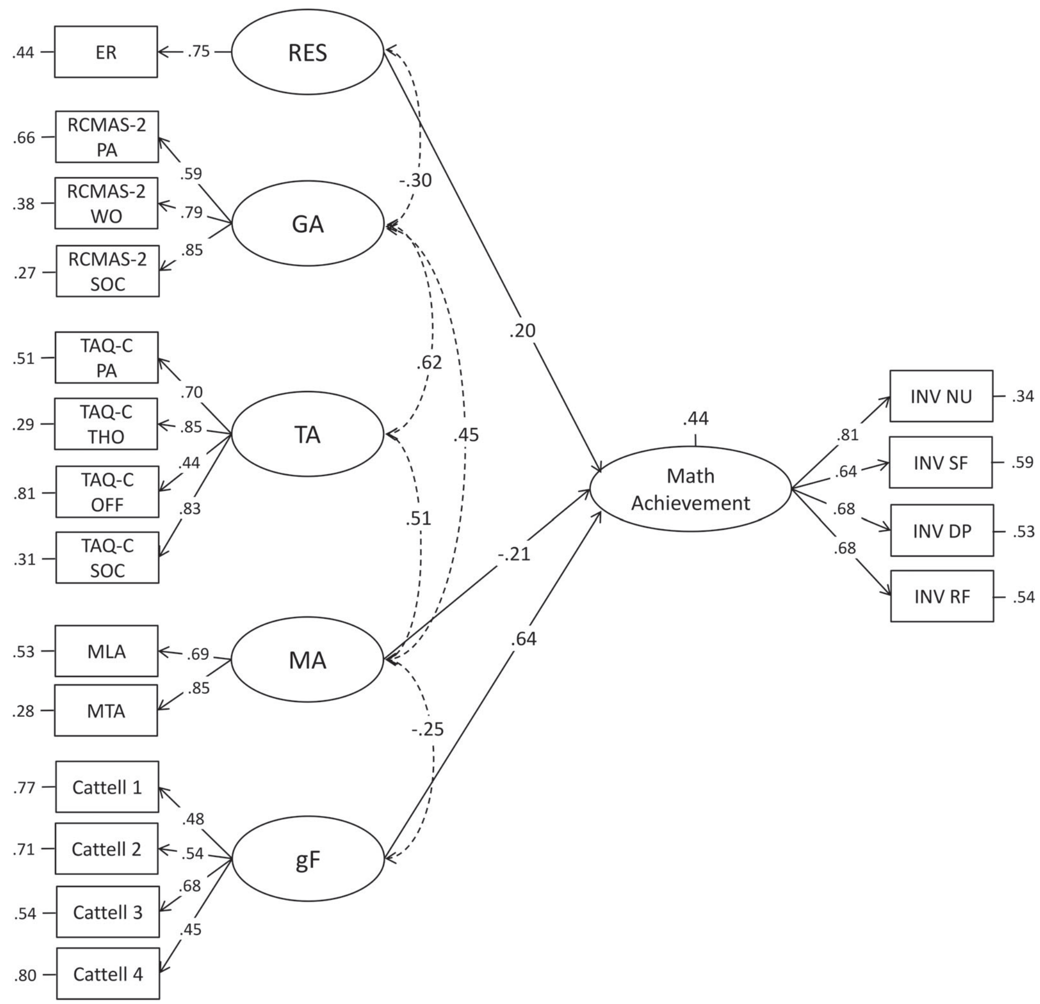

Fig 1. Final model (SEM-02) with standardized coefficients. All reported paths are statistically significant ($p < .05$). RCMAS-2 = general anxiety scale; -PA = physiological subscale; -WO = worries subscale; -SO = social subscale; TAQ-C = test anxiety scale; -PA = physiological subscale; -THO = thoughts subscale; -OFF = off-task behavior; -SO = social subscale; MLA = math learning anxiety; MTA = math testing anxiety; ER = ego-resiliency scale; Cattell = intelligence scale; MATH = mathematics literacy; -N = numbers; -SF = space and figures; -DP = data and prediction; -RF = relations and functions; GA = general anxiety; TA = test anxiety; MA = mathematics anxiety; RES = ego-resiliency factor; *g*F = fluid intelligence.

Our findings support our initial hypotheses. As regards MA, the results show a negative effect of MA on mathematics performance, strengthening the previously reported evidence of a specific association between these variables after accounting for TA and GA (Carey et al., 2017; Devine et al., 2012; Hill et al., 2016). The results of our variance decomposition analysis (see Appendix) show that MA explained a larger portion of the unique variance in mathematics performance. In other words, although MA and TA overlap to some extent, MA is more strongly associated with mathematics performance. Thus, it may be that GA and TA (i.e., being generally anxious, or worried about academic performance and academic difficulties) are risk factors that may contribute to the development of a more specific form of anxiety—MA—and therefore be indirectly related to mathematical performance (Carey et al., 2017; Mammarella et al., 2018).

As mentioned previously, we also considered the role of ego-resiliency. As expected, our findings show that ego-resiliency had a positive effect on mathematics performance. This is in line with previous studies reporting a positive association between ego-resiliency and academic achievement, and supports the conviction that ego-resiliency can be an important personal asset in relation to children's mathematical achievement (Alessandri et al., 2017; Kwok et al., 2007). Our study also aimed to see whether ego-resiliency correlated with MA and TA, and whether the associations between these variables contributed to explaining the relationship between ego-resiliency and mathematics. We found ego-resiliency negatively associated with GA, but not with TA or MA. This is in line with reports of a negative relationship between ego-resiliency and GA, pointing to it potentially protecting against general internalizing issues (Block & Gjerde, 1990; Chuang et al., 2006; Huey Jr. & Weisz, 1997; Milioni et al., 2015; Wolfson et al., 1987). Our findings suggest that ego-resiliency helps to balance individuals' adaptive capacities on an emotional level in stressful situations: higher levels of ego-resiliency would boost students' ability to manage any GA, thereby reducing any TA and MA. In short, children may face various emotional difficulties in learning mathematics, but they can also rely on ego-resilient strategies to support their achievement in this field. Ego-resiliency is considered a measure of emotional effectiveness related to high flexibility, good problem-solving capacities, persistence in challenging situations, and good emotional regulation (Eisenberg & Morris, 2002). From this perspective, the role of ego-resiliency in supporting mathematical success at school fits well with its definition as an adaptive response to demanding and high-stress situations (Block & Block, 1980; Block & Kremen, 1996). That said, our findings are not enough to confirm a moderating effect of ego-resiliency on the relationship between MA and mathematics performance (see Appendix). Further research will be needed to study this relationship in depth. In addition, the present study was cross-sectional, whereas longitudinal research will be needed to establish whether ego-resiliency can prevent the onset of GA, and to what extent these variables can support or hinder mathematical achievement over time.

The present research offers some new insight, but more research is needed, especially from a longitudinal perspective. First, future investigations should evaluate and compare the contribution of ego-resiliency together with other personal assets that may contribute to success in mathematics, such as self-efficacy and motivation (Grigg, Perera, McIlveen, & Svetleff, 2018; Hodis, 2018; Weber, Lu, Shi, & Spinath, 2013). Second, studies should adopt a longitudinal design to examine whether ego-resiliency can prevent the development of MA, and to what extent these factors could support or hinder mathematical achievement over time. Third, research is needed on environmental factors, such as teachers' and parents' expectations regarding children's academic achievement, which are known to be related to children's anxiety (Gunderson, Ramirez, Levine, & Beilock, 2012; Fennema, Peterson, Carpenter, & Lubinski, 1990; see also Chang & Beilock, 2016).

Our findings prompt some considerations regarding the promotion of children's well-being and learning of mathematics, pointing to the importance of introducing measures to manage the stress and worry sometimes associated with this school subject, and to sustain children's mathematical achievement (Caviola, Gerotto, & Mammarella, 2016). Since the direction of the relationship between MA and mathematics performance is not yet clear, it may be that children develop MA—associated with poor ego-resilient strategies—as a consequence of experiencing a poor performance in mathematical tasks. That is why future intervention studies should also include activities designed to support children's abilities in mathematics, fostering their competence in this area (Caviola et al., 2016), and examining whether improving their mathematics performance reduces the unpleasant feelings and tension they experience in situations where their performance is inadequate.

Our results also suggest the importance of developing novel interventions to contain or prevent stress and worry about mathematics at school, bearing in mind that TA and GA might be important precursors of MA (Carey et al., 2017; Mammarella et al., 2018). Early intervention and prevention programs designed to deal with TA and GA could prove very important in reducing the risk of MA. This approach would be consistent with evidence of cognitive-behavioral practice for the treatment of TA or GA proving effective in reducing MA and enhancing mathematics performance (Hembree, 1990; Supekar, Iuculano, Chen, & Menon, 2015; von der Embse, Barterian, & Segool, 2013). A possible implication of this finding is that training aimed at improving skills related to ego-resiliency might also reduce MA symptoms and sustain mathematics performance. Specific activities should be promoted directly in schools to help children develop new skills in areas such as problem solving, communication and meta-cognition (Caviola, Mammarella, Cornoldi, & Lucangeli, 2009; Elias et al., 1986; Kramarski & Mevarech, 2003; Middlemiss, 2005). Previous research found that evidence-based strategies enhanced emotional regulation—a construct related to ego-resiliency particularly important in children (Webster-Stratton, Jamila Reid, & Stoolmiller, 2008). Therefore, specific intervention programs designed to boost children's emotional regulation could be helpful, especially for children at risk of internalizing problems (Haggerty & Mrazek, 1994).

Finally, it is important to consider that mathematics is a domain where the emotional difficulties children often face can be due to weak self-management skills when coping with frustrations or setbacks (Covington, 1992). Some children may experience a lack of subjective control (i.e., a low ego-resiliency) when learning mathematics due to the characteristics of this particular subject, which demands skills and effort to achieve a good performance (Devine et al., 2018). A good subjective control over achievement could act as an important factor in containing anxiety (Pekrun, 2006; Pekrun & Perry, 2014). Teachers could therefore focus on strengthening their children's control appraisals instead of stressing the importance of the learning domain, especially in the case of mathematics. Teachers could be encouraged to develop classroom environments that reinforce children's internal control, by supporting their autonomy, and giving them clear goals and expectations, for instance, to facilitate their anxiety-free learning (Hulleman, Barron, Kosovich, & Lazowski, 2016; Pekrun, 2006). These aspects are particularly important to help children face difficulties at school, and support their academic success in primary and middle school (Martin & Marsh, 2006).

To sum up, two conclusions can be drawn from our study: our results confirm the specific link between mathematics and MA; and this association is countered by the positive effect of ego-resiliency in enhancing mathematical learning. As extensively discussed, these results have important implications for improving the learning of mathematics. Implementing specific intervention programs to target anxiety, and informing parents and teachers about useful strategies for sustaining ego-resiliency could help to reduce children's MA at school, thereby improving their well-being and mathematical success.

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APPENDIX 1: ADDITIONAL ANALYSES

SENSITIVITY ANALYSIS TO MULTIVARIATE OUTLIERS

A sensitivity analysis was conducted to see whether our results were affected by multivariate outliers. The Mahalanobis distance calculated on the 18 variables observed in the sample ranged between 5.37 and 38.71 ($M = 17.93$, $SD = 6.34$). The final model (SEM02) was fitted again on a subsample of participants after removing observations with a Mahalanobis distance over 28 (i.e., up to 20 participants were removed). The results showed that the standardized paths changed very little (they never varied by more than $\pm.02$), and the correlations remained relatively stable (with a variation of $\pm.07$). All coefficients, including paths, correlations, and loadings, remained statistically significant, confirming that our results were robust and stable.

SENSITIVITY ANALYSIS ON GENDER

A sensitivity analysis was also conducted to see whether the paths were affected by gender. After partializing all 18 observed variables for gender, all standardized paths and correlations in our final model (SEM02) were much the same (they varied by less than .03), and still significant. The fit indices of the final model remained unaltered. These results confirm that our findings are robust even after controlling for the effect of gender.

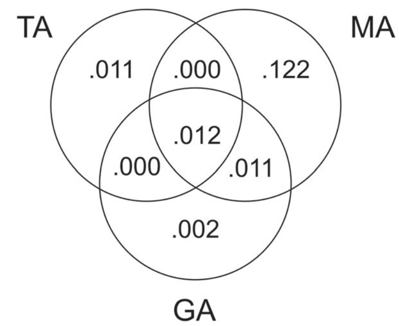

Fig 2. Venn diagram indicating the shared and unique variance explained in mathematics by GA (general anxiety), TA (test anxiety), and MA (mathematics anxiety).

MODERATION ANALYSIS

Based on theoretical considerations, we tested for a possible moderating effect of ER on the relationship between MA and MATH. We added an interaction term between ER and MA on MATH to the final SEM model shown in Figure 1. As the "lavaan" package of R does not currently allow for the fitting of interaction effects between latent variables, the same model was fitted in Mplus. The results suggested that the interaction term reduced the model's fit, $\Delta AIC = +1.36$, and it was far from significance, though it pointed in the expected direction (a higher RES corresponded to a slightly lower effect of MA on MATH) $B = .02$, $p = .27$. In other words, there was no evidence to suggest such a moderating effect. That said, there was no evidence against it either, because the present study was not designed to have the power needed to reveal such a subtle effect as an interaction.

VARIANCE BREAKDOWN

We used a variance partitioning analysis to examine the unique and shared portions of variance explained by MA, TA, and GA on MATH. We conducted a series of regression analyses to obtain R^2 values from different combinations of predictor variables to partition the variance of our outcome (i.e., MATH). Interfactor correlations were used for each variable entering the regression (Chuah & Maybery, 1999). As shown in Figure 2, MA explained a larger portion (i.e., 12%) of the unique variance on MATH. Interestingly, the larger portion of the variance is shared between these variables.